Double-Longitudinal Spin Asymmetry in Non-Identified Charged Hadron Production in pp Collision at $\sqrt{s} = 62.4$ GeV at PHENIX

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Abstract. Charged hadron asymmetry measurements at PHENIX are interesting because of their possible sensitivity to both the sign and the magnitude of Δg. Hadron production in *pp* scattering at $\sqrt{s} = 62.4$ GeV with transverse momentum < 5 GeV/c is dominated by quark-gluon scattering at leading order in pertubative QCD, providing sensitivity to the gluon helicity distribution in the proton. Within the PHENIX central arm [3] pseudo-rapidity coverage of $-0.35 < \eta < 0.35$, these measurements probe the scatering of partons with momentum fraction 0.05-0.2 [2]. The double longitudinal spin asymmetry of non-identified charged hadrons will provide new data points for extracting gluon polarization.

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INTRODUCTION

The gluon helicity distribution has been of interest to physicists trying to understand proton spin structure since the European Muon Collaboration constrained the contribution of quarks to proton spin. Later experiments (e.g. HERMES, SLAC, SMC) measured quark contribution to be 0.33 [4].

At the hard scale of interaction, the total cross-section (σ) of the polarised proton-proton scattering process can be factorized into distribution function (f_a, f_b) of partons, cross-section ($\widehat{\sigma}$) of partonic scattering and fragmentation ($D(z)_h$) of partons into final state particles (e.g. hadon h with momentun fraction z of the parent parton). The double longitudinal spin asymmetry, which is defined as:

$$A_{LL} = \frac{\sigma^{++} - \sigma^{+-}}{\sigma^{++} + \sigma^{+-}} \tag{1}$$

$$A_{LL} = \frac{1}{P_1 P_2} \frac{N^{++} - RN^{+-}}{N^{++} + RN^{+-}} \tag{2}$$

can be related to these quantities in the following way:

$$A_{LL} = \frac{\sum_{a,b=q,\bar{q},g} \Delta f_a \otimes \Delta f_b \otimes \Delta\widehat{\sigma} \otimes D(z)_h}{\sum_{a,b=q,\bar{q},g} f_a \otimes f_b \otimes \widehat{\sigma} \otimes D(z)_h} \tag{3}$$

$$\tag{4}$$

where $N^{++}(N^{+-})$ is the number of final state particles from same (opposite) helicity configuration of colliding protons, R is the Relative Luminosity of same and opposite helicity, P_1, P_2 are the beam polarizations and Δ indicates the difference of the quantity between same and opposite helicity configurations.

Contributions from different partonic subprocesses (quark-quark, quark-gluon, gluon-gluon) in the production of particles vary with transverse momentum (pT) range of the final state particle. Theoretical calculations (Figure 1) lead us to believe that in $\sqrt{s} = 62.4$ GeV pp collisions, charged hadron production in the range of p_T $(0.5 - 4.5 GeV/c)$ is dominated by quark-gluon processes, thereby rendering the measurement of asymmetries sensitive to gluon polarization (Δf_g or, simply, Δg) inside proton.

Another interesting aspect of charged hadron asymmetry is a possible signature of the sign of Δg. A positive Δg would be manifest in the ordering of asymmetries of pion production as:

$$A_{LL}(\pi^+) > A_{LL}(\pi^0) > A_{LL}(\pi^-) \tag{5}$$

whereas for a negative Δg, the ordering will be the opposite way. As charged pions are the bigest contributors in the charged hadron samples analysed, we may hope to see the same signature in charged hadron asymmetries.

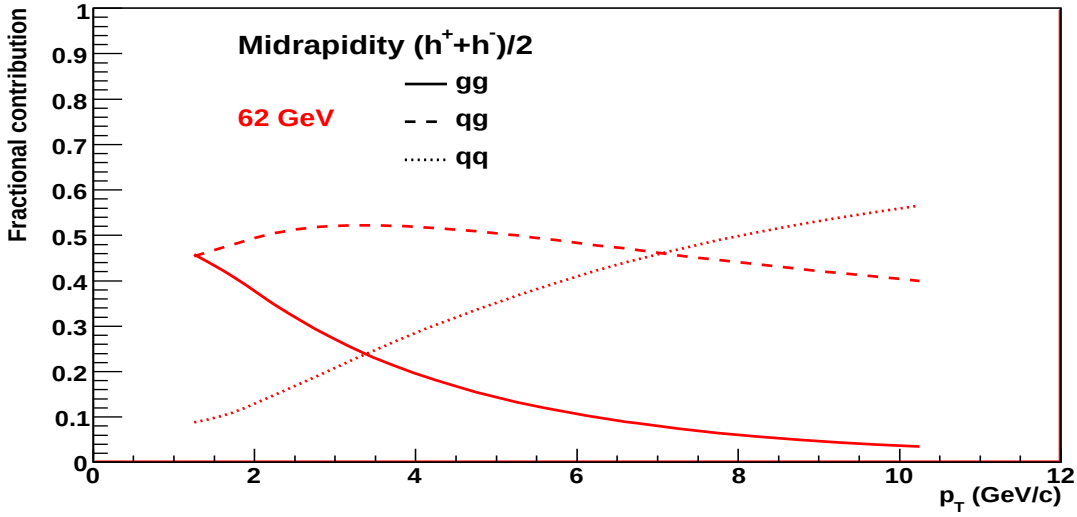

FIGURE 1. Contribution of subprocesses as function of transverse momentum (From W. Vogelsang).

MEASUREMENTS AND BACKGROUNDS

A total integrated luminosty of the $0.08 pb^{-1}$ of polarized pp collisions at $\sqrt{s} = 62.4 GeV$ was recorded in one week at RHIC during 2006. About $40 nb^{-1}$ data triggered by requiring coincidence of hits on Beam Beam Counter [3] on both sides of nominal interaction region (PHENIX Minimum Bias trigger) were used for analysis. Average polarizations of the two beams were $\sim 48\%$ for the data set analysed. In the PHENIX

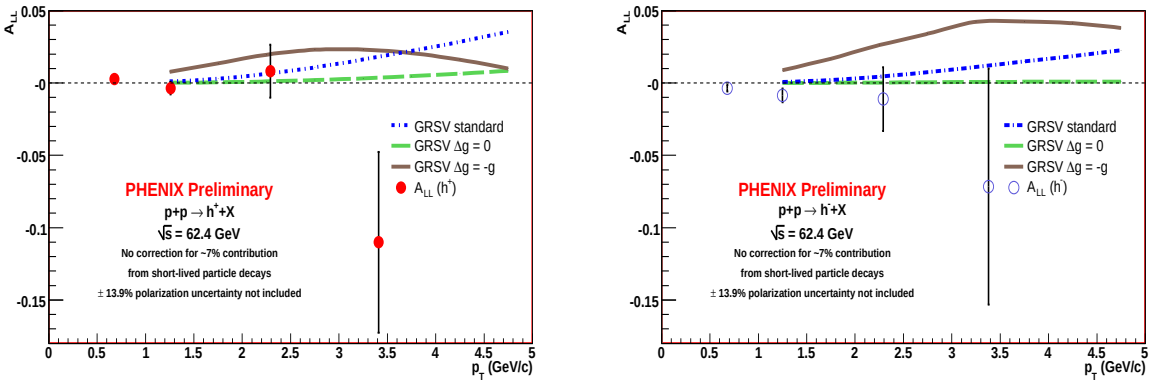

FIGURE 2. Preliminary result for A_{LL} of positive(left) and negative(right)hadrons in polarized proton proton collision at $\sqrt{s} = 62.4$ GeV.

detector system, charged tracks are reconstructed using Drift Chamber [3] and Pad Chambers [3]. High quality tracks with the additional requirement of hits on outer layer of Pad Chamber were selected for the analysis.

Electrons and positrons are some of the biggest cotributors to the background for the charged hadron candidates. However, Ring Imaging Cherenkov (RICH) [3] detector at PHENIX is fired by electrons and positrons with very low energy (17 MeV) as opposed to hadrons. Pions, the lightest of the hadron candidates, fire RICH at 4.7 GeV and heavier hadrons require even more energy. Electron and positron backgrounds were, therefore, removed efficiently by vetoing on RICH hits.

Another source of background is the decay products from weak decays of hadrons. Hadrons with typical $c\tau \sim 1 - 10$ m decay far from event vertex and the low momentum decay products often contribute to the background. We estimate the background by looking into the distribution of hits in outer detectors and correct the asymmetry measurement for the background asymmetry.

RESULT

Preliminary result for the double spin asymmetries of charge-separated hadrons along with the corresponding predictions using GRSV framework [1] with three different initial Δg assumptions are presented in Figure 2. Calculations for the predictions were done using DSS fragmentation and at factorization and renormalisation scale of $\mu = p_T$. We also show the comparison of charged hadron double spin asymmetries with neutral pion double spin asymmetry measured [5] at PHENIX at the same energy in Figure 3.

CONCLUSION

Longitudinal double spin asymmetry of charged hadron production in polarized proton proton collisions was found to be consistent with the small gluon polarization measured

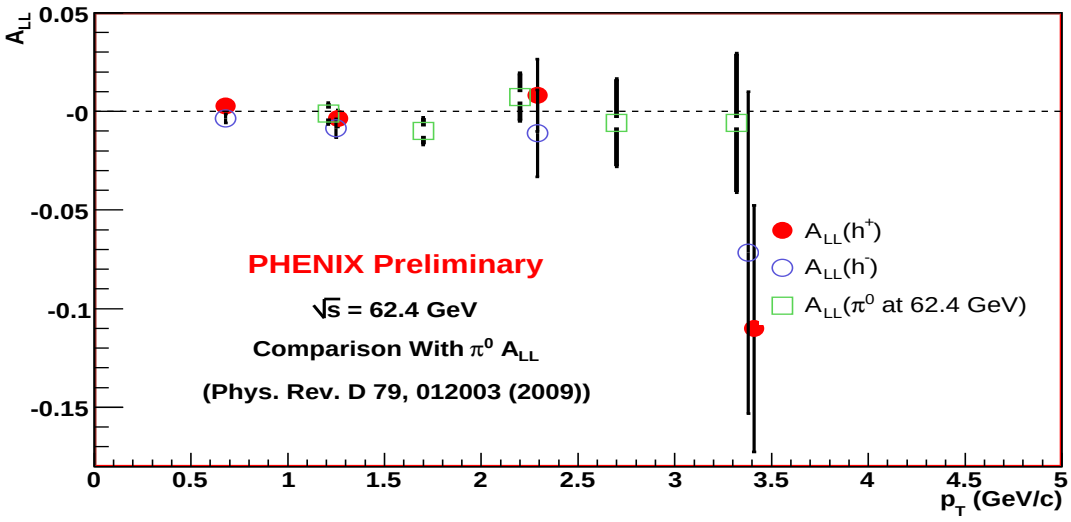

FIGURE 3. Comparison with neutral pion A_{LL} at $\sqrt{s} = 62.4$ GeV.

by other probes (e.g. neutral pions) in similar range of parton momentum fraction (x) at PHENIX [5] [6]. The results disfavour the models with significantly large positive or negative Δg. Cross-section measurements of charged hadron production are in progress and will be compared with NLO and NLL calculations. The published result of neutral pion cross-section [5] from 2006 run at $\sqrt{s} = 62.4$ GeV already show good agreement with theoretical predictions [2] using GRSV framework and suggests that NLL corrections may be relevant at this energy. Although inconclusive in the present analysis, with enough statistics in future runs, the asymetry measurement of charged hadrons may be useful in indicating the sign of Δg.

ACKNOWLEDGMENTS

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